METROPOLITAN
WATER WORKS
AUTHORITY

FEASIBILITY STUDY
FOR
THE EXPANSION SYSTEM
OF
METROPOLITAN WATERWORKS
IN
BANGKOK, THAILAND

FINAL REPORT

JULY, 2521 (1978)

JAPAN INTERNATIONAL COOPERATION AGENCY

โครงการประปาระบบอิสระ

FEASIBILITY STUDY FOR THE SEPARATE SYSTEM OF METROPOLITAN WATER SUPPLY IN BANGKOK, THAILAND

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PREFACE

In response to the request of the Government of Thailand, the Government of Japan decided to cooperate in the execution of a feasibility study for the Separate System of the Metropolitan Water Supply in Bangkok which covers not only the 9 Amphoes but also the adjacent industrial estates and/or residential development areas of the Amphoes, and the Japan International Cooperation Agency (hereinafter referred to as J.I.C.A.) undertook the study.

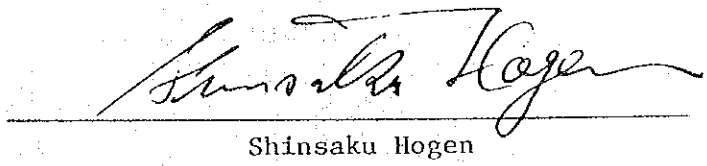
J.I.C.A. carried out the first field survey between January and March, 1977, and the second field survey between October and November, 1977.

After further studies in Japan, the interim and draft final reports were submitted and explained to the Government of Thailand in October,1977 and May, 1978, respectively. The study is now completed and is contained in this final report.

I sincerely hope that this report will contribute to the development of the Separate System Project and to the friendly relations and understanding between the two countries.

I wish to express my thanks to the competent Thai authorities, other agencies and the many other people concerned for their helpful cooperation and valuable advice which made a significant contribution to the execution of this study.

July, 1978



Shinsaku Hogen
President
of
JAPAN INTERNATIONAL COOPERATION AGENCY

C O N T E N T S

CHAPTER I INTRODUCTION

CHAPTER 1

INTRODUCTION

1-1 Foreword

The water supply in metropolitan Bangkok was previously under the jurisdiction of the Bangkok Water Supply Division, Public Works Department, Ministry of Interior of Thailand; but was transferred to the Metropolitan Water Works Authority (M.W.W.A) and which was established in 1969 as one of the public-owned enterprises which belonged to the Minister of Interior and operated on their own account.

M.W.W.A placed an order for planning the expansion of the metropolitan Bangkok water supply with the U.S. consulting firm of Camp, Dresser & McKee (hereinafter referred to as C.D.M.) in December 1968. The choice of the consultant was made by the Board of Directors of M.W.W.A. from among many applicants from such countries as Japan, Thailand, U.S.A. and Great Britain. On being awarded the order, C.D.M. started a survey and finished its master plan of the metropolitan water supply project in February 1970.

The master plan consisted of two parts, "Summary Report" and "Technical Report". The basic concept embodied in the master plan consisted in dividing the entire M.W.W.A. service area into two service areas: a central system, and a separate system. The master plan placed the population of the service area in year 2000 at 9,920,000, the house connection ratio in 2000 at 86%, and the maximum daily water demand in 2000 at 5,500,000 CMD, and gave an estimation of construction cost amounting to about 600 million dollars. The separate system considered by C.D.M., however, was a relatively simple water supply system and for which C.D.M. estimated the total population of the service area, house connection ratio, population to be served and maximum daily water demand in 2000 at 305,000, 74 %, 225,000 and 36,000 CMD, respectively, and its total construction cost was only about 7 million dollars. The separate system was planned to cover an administrative area of 1,553 km^2, and which comprises 9 Amphoes

surrounding the central system. The community people of this area now live mainly by agriculture, but it is taking on an aspect of a residential area of metropolitan Bangkok. Furthermore, industrialization is also taking place, though slowly, and the construction of an international airport and a university town is planned.

According to the master plan presented by C.D.M, M.W.W.A. placed an order for detail design of the first stage (completion set for 1977) construction of the central system with C.D.M, and its construction is now under supervision of the U.S. consulting firm of Metcalf & Eddy. On the other hand, the Department of Technical & Economic Cooperation (hereinafter referred to as D.T.E.C.) requested the Japanese government for technical cooperation in the detail design of the separate system in September 1971, asking it to approve that Dr. Sachiho Naito who had working for the Provincial Water Supply Division, Public Works Department, Ministry of Interior of Thailand, as a sanitary engineer according to the Colombo Plan, would also work for M.W.W.A.

The Japanese government consented to place Dr. Naito on the water supply project for M.W.W.A. and also promised to consider technical cooperation with Thailand in the 1972 budget. Dr. Naito carried out a basic survey of Amphoe Nong Khaem by March 1971 when his contract term terminated, but he continued to work on his prefeasibility study in his private capacity in Japan. In January 1972 he presented a prefeasibility study report to Prof. Chamras, General Manager of M.W.W.A.

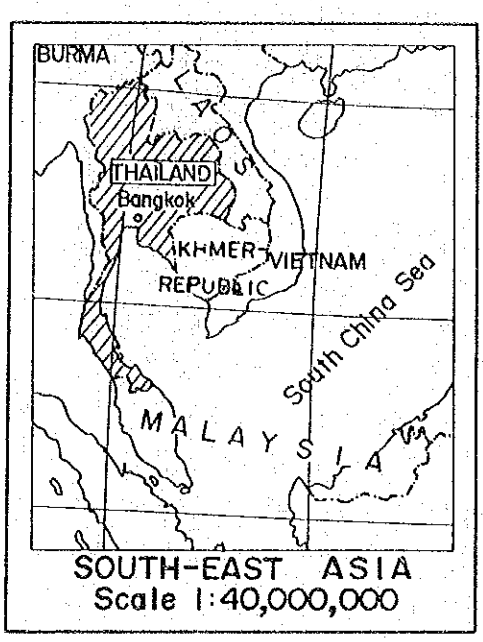
The Japanese government examined the master plan of C.D.M. on the one hand, and on the other also studied whether the 1972 budget would permit extension of cooperation to Thailand in the form of a feasiblity study of the separate system; but then reached the conclusion that it was difficult to prepare the detail design of the separate system only on the basis of the master plan of C.D.M. As a result, the Japanese government recommended that an entirely new feasibility study of the separate system should be undertaken, and also notified that since the 1972 budget and time would not permit undertaking a survey of all the 9 Amphoes named by M. W. W. A., it

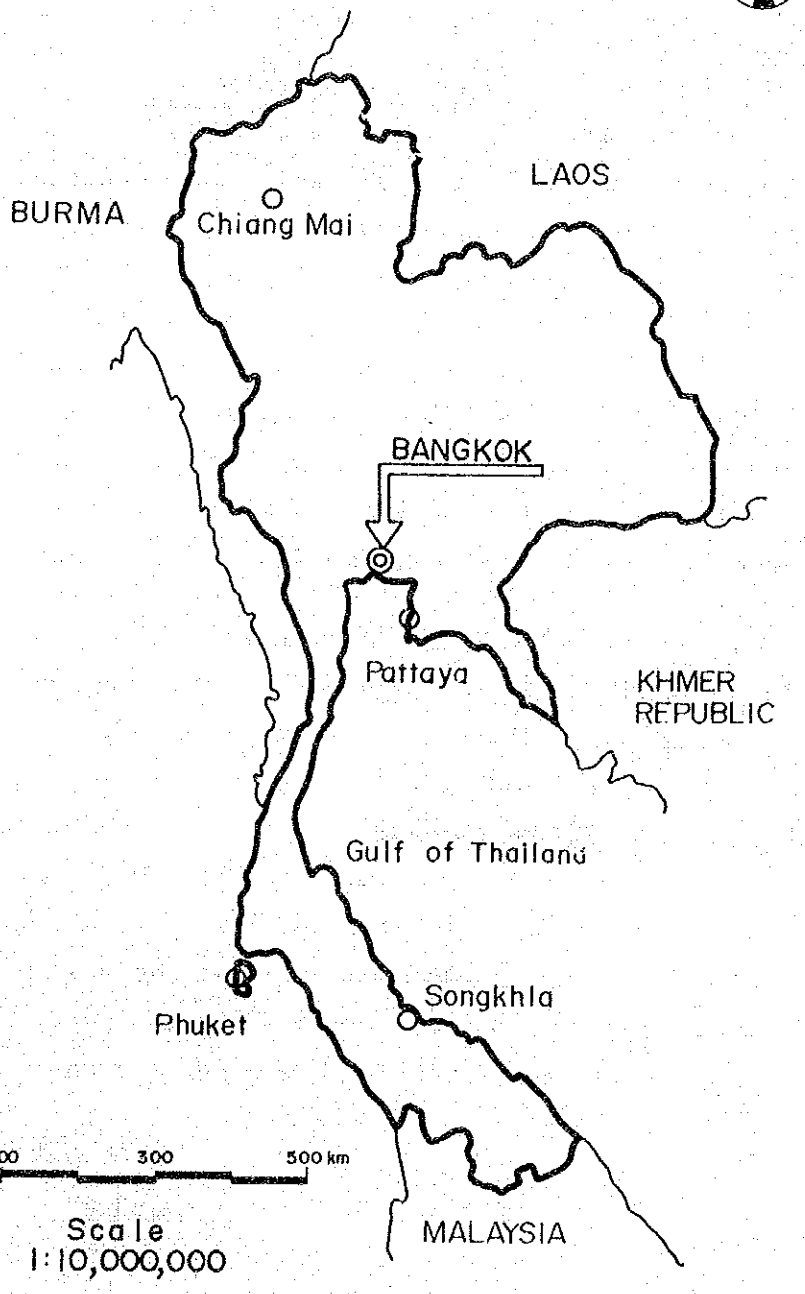
would agree to undertake a survey of 5 Amphoes during fiscal 1972. According to this decision by the Japanese government, the first Japanese survey team started a survey in March 1972 and "Feasibility Study Report for Separate System" for 5 Amphoes was submitted to the government of Thailand in March 1973.

The survey of the remaining 4 Amphoes remained a question to be settled between the two countries until 1977. However, J.I.C.A. undertook the task consequently and surveyed the 4 Amphoes for 3 months starting in January 1977. Prior to this survey M.W.W.A also requested J.I.C.A. to include the housing and industrial program areas which were planned to be developed one after another in the vicinity of the service area of the separate system, and J.I.C.A gave a conditional consent to this request from M.W.W.A.

The Metropolitan Water Supply Project in Bangkok has a history of many years, and this final report represents a summary of the feasibility study of its separate system which was conducted with the energetic cooperation of J.I.C.A. and many sanitary engineers and other experts over a span of about 7 years.

Fig 1-1 LOCATION MAP





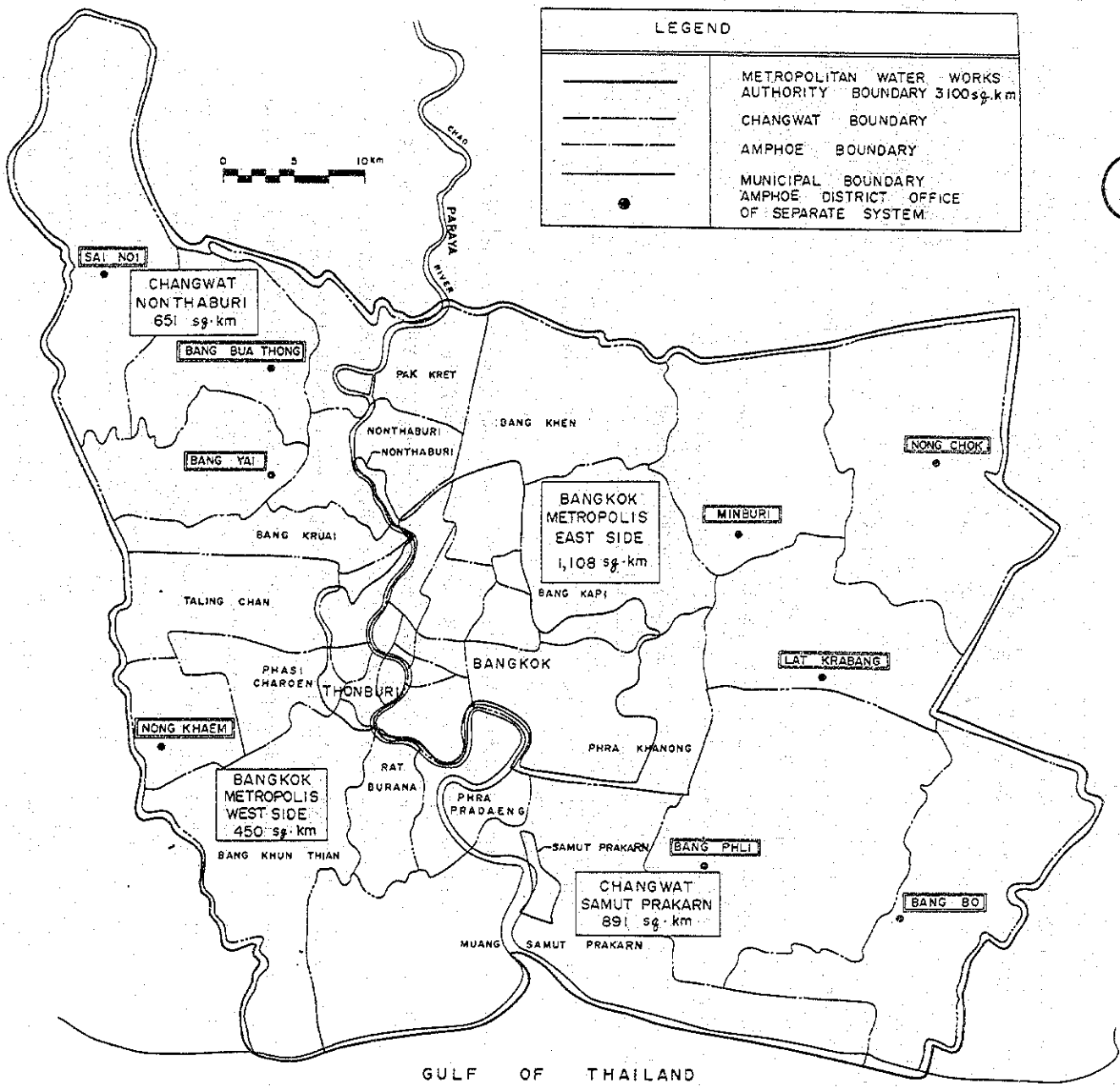


Fig 1-2 PLAN OF METROPOLITAN WATER WORKS AUTHORITY AREA

1-2 Significance of Feasibility Study and Outlook

The social environment which has influence on a water supply greatly changes from year to year. The growth and expansion of cities today depends on the trend in industry and the concentration or dispersion of population and does not run a fixed course. Any water supply project should therefore be planned with a sufficient degree of flexibility to adapt it to the changes in its proposed service area so as to ensure the balance in water demand and supply.

The water supply project should be planned as a comprehensive project which blend with the regional characteristics of the area it covers. If the water supply project is planned from only an administrative point of view such as village, town, city and/or country, the effective utilization of the water resource, the proper distribution of water among various demands and the flexible operation of the water supply facilities will not be satisfied enough. Furthermore, a useless double or triple investment will be unfortunately made.

This report on the feasibility study of the "Separate System of Metropolitan Water Supply Project in Bangkok" contains, as its name implies, the results of a feasibility study of a separate water supply system planned to cover the 9 Amphoes surrounding Bangkok city and the related housing and industrial project areas. The important points of this feasibility study were the water source and the relationship between the separate system and the central system.

These two important points are also closely related to each other, however, especially the latter is considered to be most important because the central system is already under construction and its completion set for 2000. C.D.M. stated in its report submitted to M.W.W.A. in February 1970 that the separate system should be planned independently of the central system. However, when the changes in their environmental conditions are taken into account, it seems open to question whether C.D.M. view is still valid. That is, a question now arises as to whether the separate system project can be planned only from the standpoint of a water supply for the 9 Amphoes and related housing and industrial project areas.

However, it is also a fact that the comprehensive water supply project is rational on the one hand, while on the other it is irrational in that it needs a long construction period and involves a heavy investment. The public water supply is a nonprofit undertaking and is not allowed to raise the water charge to the consumer as easily as it desires. To avoid the heavy burdens of interest and depreciation expenses, the water supply authority naturally tries to cut the first cost of the water supply project as far as it can, eventually reducing the scale of the project depending on the case.

The separate system is a typical example. A part of the proposed service area of the separate system is now under the jurisdiction of the Provincial Water Supply Division, Public Works Department, Ministry of Interior and in this part water has never been charged for at a rate of more than 2 Bahts/m^3. In part, because of this historical background, the water supply authority seems to have little mind to promote a long-term, comprehensive water supply project which would put a heavy strain on its financial resources.

J.I.C.A., squarely facing the fact that the community poepole of the 9 Amphoe Towns have long suffered from a water supply shortage, has conceived an emergency program by which to allow them the privilege of using groundwater, and proposed its feasible plan to M.W.W.A. The plan is discussed in detail in Chapters 2 and 7.

However, as a further field survey is necessary to develop the feasible plan into a detail design, J.I.C.A. made relevant recommendations to M.W.W.A., as summarized below.

The water supply project has hitherto been planned by using an indirect approach consisting of electrical prospecting method and consultation of the data of the past years instead of employing a direct method, boring. For instance, the coefficient of aquifer could not be estimated otherwise than by consulting the data obtained in metropolitan Bangkok and the specific capacity of the existing wells.

The proposed service area of the separate system is, of course, an important area of recharge to metropolitan Bangkok. Now that it can hardly be expected that water is directly returned to the aquifer

from the ground surface, to have control of the aquifers is by far more important than before from the standpoint of groundwater utilization. Aquifer control makes it an aim to determine the influence of groundwater utilization on the aquifer, to estimate the resulting change in the groundwater level, to prevent the undesirable consequence resulting from abnormal decline of the groundwater level and to prevent an unnecessary investment by planning the capacity of production wells according to the capacity of aquifers tapped.

In planning the separate system, it is necessary to review and forecast the changes of the groundwater level resulting from ground water use through 2000, based on the coefficient of aquifer to be tapped which would be estimated by the direct boring before the detail design. To this end, it should be recommended to take the following actions:

(1) A set of test wells should be bored to the planned depth in each Amphoe, including:

1) Test wells

A set of lifting and observation wells should be bored at 8 locations.

2) Electric logging and γ -logging should be carried out.

3) Yield tests should be performed to determine the coefficients of transmissibility, permeability and storage of aquifers to be tapped and the specific capacity of wells.

4) Analysis of water quality and grain size of aquifer sand.

(2) Information on the causal relation between the annual increase in groundwater pumpage on the one hand and the draw-down of the groundwater level, the salification of groundwater and land subsidence on the other should be obtained.

(3) The draw-down of the groundwater level due to groundwater use by the separate system will be mathematically simulated. That is, the groundwater balance in each Amphoe will be computated by using a mathematical model of the aquifer.

The proposed long-term, comprehensive water supply plan represents the most feasible of all the alternative cases in which the separate system is assumed to form a part of the central system. Since this plan presupposes the tapping the sources of surface water, including the Chao Phraya river, it is of absolute necessity to obtain prior consensus of the authority having rights to the sources of surface water to implement the long-term comprehensive water supply project. The development of water sources is not a matter which the water supply authority alone can decide upon since such a project is of national concern. The government of Thailand is therefore urged to undertake such a national project so as to pave the way for the promotion of regional water supply projects, as will be discussed in detail in Chapters 2 and 7.

Since it is within the power of M.W.W.A. to decide to divert water from the central system, it should consider the redistribution of water in planning the long-term comprehensive water supply system.

1-3 History of Activities of Separate System Project Survey Team

1-3-1 First Field Survey (January 23 to March 26, 1977):

(1) Introduction:

After the completion of the first feasibility study of separate system (1973) by the Japanese survey team, M.W.W.A. wanted the Japanese government to continue its cooperation and explained that it wished to secure budgetary support from the government of Thailand by clarifying the condition of the water supply in all the 9 Amphoes. On the other hand, the concentration of population in the built-up districts of metropolitan Bangkok became advanced with time until people began to move out of central Bangkok into the suburban districts. As a result, the order of priority of water supply which was decided in 1973 had to be changed. Furthermore, times were changing such that housing and industrial projects were planned in the sparsely populated districts between the Amphoes.

In 1976 budget the Japanese government decided to review the feasibility study of the 5 Amphoes and to carry out a field survey of the remaining 4 Amphoes. As in the first feasibility study, the Japanese government appointed Pacific Consultants International and Nakanihon Engineering Consultant as a joint contractor of the second feasibility study. The study team organized by the coalition was accompanied by Dr. Naito, Technical Adviser to the Japan Water Works Association, and Mr. K. Okazawa, Sanitary Engineer of the Ministry of Health and Welfare, as supervisors when the team visited Thailand to arrange with M.W.W.A for the field survey.

The study team from Japan as proposed was accepted by M.W.W.A. and in due course M.W.W.A. kept vehicles in readiness, prepared an office and offered competent Thai counterparts; while satisfactory arrangements were also made with the M.W.W.A. executive staffs for the field survey and feasibility study.

(2) Scope of Work:

The study team consisted of 12 members. Of them, Dr. Naito, Mr. Okazawa, Mr. Shiozawa and Mr. Miyakura visited Thailand before the

other members (Mr. Kawamura, Mr. Kawabata, Mr. Komatsu, Mr. Nakamura, Mr. Hashiji, Mr. Takemoto, Mr. Muto and Mr. Ogawa) and discussed with M.W.W.A. executive staffs about the Scope of Work on January 25 and 26, 1977.

The Thai side expressed their hope that, instead of limiting its activities to the 9 Amphoes, the Japanese study team would take a flexible survey toward new developments such as the industrial site adjacent to Min Buri, the fishing port area which needed to be supplied water from Bang Bo, and a new airport planned to be built near Lat Krabang. The Thai side also expressed their hope that the separate system would be reviewed from various angles, especially in connection with the central system in which the Phase 1 Project (800,000 CMD) of the 1st stage is now under construction.

Although the budget and time did not permit the inclusion of all new development program areas in the Scope of Work of the feasibility study, the Japanese survey team recognized the necessity of surveying the districts adjacent to the 9 Amphoes. As a result, the Minutes of Meeting were prepared so as to confirm mutual understanding of the matters which could not be included in the Scope of Work, and General Manager Mr. Krachok of M.W.W.A and Chairman Dr. Naito of the Japanese Feasibility Study Team put their hands to the Minutes of Meeting attached hereto.

On the other hand, the review of the separate system in connection with the central system was not included in the Scope of Work, in part because it would give rise to complex implications and would probably involve the evaluation of the data prepared before. For the present, therefore, the proviso that the separate system would be planned in such a way as to avoid any modification of the plan of the central system, was added to the above Minutes of Meeting on the one hand, and on the other it was agreed between the Thai and Japanese sides that the transmission line desired by the Thai side would be considered separately.

In connection with the feasibility study, the Thai side also expressed their hope that the technical staffs of M.W.W.A. would be trained in Japan, but it could not be included in the Scope of

Work, in part because of a problem associated with the desired period of training and the mechanism of J.I.C.A. Then, a clause that the individual training in Japan of two engineers and one economist from M.W.W.A. would be accepted by the Japanese side at a relatively early date, was inserted in the Minutes of Meeting.

The Scope of Work reflecting the above considerations was agreed on by and between J.I.C.A. and D.T.E.C. of Thailand on January 26, 1977.

SUMMARY OF DISCUSSION

ON

THE SEPARATE SYSTEM

OF

METROPOLITAN WATER SUPPLY PROJECT IN BANGKOK

The Japanese Feasibility Study Team for the Separate System of Metropolitan Water Supply Project in Bangkok and The General Manager of Metropolitan Water Works Authority (MWWA) as well as the representative of the Department of Technical and Economic Cooperation (DTEC) of Thailand, had discussed and exchanged opinions in regarding to the Separate System of Metropolitan Water Supply Project. The discussion had been taken place at the MWWA office on January 26, 1977 respectively.

The discussion had brought various matters to the attention of the authorities concerned and summarized the following considerations:

1. The Japanese Feasibility Study Team and the Metropolitan Water Works Authority agreed in principle that the feasibility study will be conducted based on the scope of work attached herewith, considering following items;

   (a) the studies will not include the reviewing of the central water supply system but the planning of piping system in case that the separate system would be better to branch the water from the central system.

   (b) the studies will cover adjacent industrial and/or residential areas concerning to nine Amphurs, if necessary.

2. The General Manager of MWWA will request counterparts training (two engineers and one economist) during the feasibility study in Japan.

Attachments are as follows :

1. Scope of work for Feasibility Study for the Separate System of Metropolitan Water Supply in Bangkok, Thailand (Attachment I)

2. List of Attendants (Attachment II)

26th January 1977, Bangkok.

Sachio Naito
Chairman,
Japanese Feasibility Study Team
for the Separate System of
Metropolitan Water Supply Project

Krachok Supkitvilekkarn
General Manager,
Metropolitan Water Works Authority
of Thailand

Attachment I

SCOPE OF WORK

FEASIBILITY STUDY FOR THE SEPARATE SYSTEM OF METROPOLITAN WATER SUPPLY IN BANGKOK, THAILAND

1. Introduction

In response to the request of the Government of Thailand, the Government of Japan has agreed to conduct a feasibility study of nine Amphoes (districts) of the Separate System of the Metropolitan Water Supply of Bangkok.

In accordance with laws and regulations in force in Japan, this study will be carried out by the Japan International Cooperation Agency (JICA), the agency of the Government of Japan responsible for the implementation of international technical cooperation programs.

At all stages the study is to be carried out in close cooperation with the Government of Thailand and with the Thai Authorities concerned.

2. Objectives of the Study

The objectives of the study are as follows:

(a) To carry out a feasibility study of the water supply system in the four Amphoes (districts) of Min Buri, Nong Chok, Bang Phli and Bang Bo.

(b) To review, and if necessary up-date and revise, the feasibility study of the water supply system in the five Amphoes (districts) of Nong Kaem, Lat Krabang, Bang Bua Thong, Bang Yai and Sai Noi, which was carried out in 1972 by OTCA (JICA's predecessor).

(c) To recommend a master plan for the water supply system of the nine Amphoes (districts) mentioned above until the year 2000 including layout and characteristics of the main facilities, priorities and costs.

3. Outline of the Study

1) Field Survey

(1) Data Collection

(a) Information on labor conditions, labor cost, construction materials, construction cost, construction machines, and design standard

(b) Laws and regulations

(c) Existing city planning, including population estimation in future

(d) Existing geological and soil testing data

(e) Meteorological data such as wind direction, wind velocity, temperature, rainfall, etc.

(2) Analysis of existing water supply system

(a) Possibility of improvement of present facilities

(b) Possibility of extension of present capacity

(3) Water reconnaissance

(a) Various investigations of existing canal or klong

(b) Quality and quantity of Chao Phya River and Nakorn Chai Si River throughout a year

(c) Analysis of existing wells in the project area

(d) Ground water test in left bank of Chao Phya River by means of Electrical prospecting method

2) Detailed study in Japan

(1) Population forecast for 2000 AD

(2) Water demand forecast for 2000 AD

(3) Proposed water sources and sites of water facilities and distribution area

(4) Layout plan of the following basic facilities in connection with item (3)

(a) Water intake facilities including pump, intake tower, receiving well or deep well

(b) Raw water main

(c) Purification facilities including mixing basin, flocculation basin, sedimentation basin, rapid sand filter, elevated tank for washing, clear water tank

(d) Transmission line

(e) Distribution facilities including clear water reservoir, distribution main, distribution pump or elevated tank

(5) Cost estimation

(6) Construction schedule in stages

(7) Economic and financial analysis including water rate analysis

4. Reports

The JICA will prepare and submit the following reports to the Government of Thailand

1) Inception Report (30 copies)
- Details of the study items, working diagram and others
- At the beginning of the field survey

2) Progress Report (30 copies)
- At the end of the field survey

3) Interim Report (50 copies)
   - Within 4 months after the completion of the field survey
   - The Government of Thailand is requested to provide the JICA with its comments within one month after the receipt of the interim report

4) Draft Final Report (30 copies)
   - Within 4 months after the receipt of the comments on the interim report
   - The Government of Thailand is also requested to provide the JICA with its comments with one month after the receipt of the draft final report

5) Final Report (50 copies)
   - Within 2 months after the receipt of the comments on the draft final report

5. Undertaking of the Government of Thailand

1) To provide the study team with data and information necessary for study

2) To exempt the study team from the taxes and duties on the materials, equipment and personal effects brought into Thailand by the study team. This is normally applied to the Colombo Plan experts

3) To appoint the official counterparts of the study team during survey period

4) To provide the study team with suitable office space with necessary equipment for the study

5) To make necessary arrangements for the study team to bring the data and materials concerning the study into Japan.

6) To provide the study team with necessary office facilities and means for the study, such as vehicle, photo-copier, type-writer, calculator, etc.

6. Undertaking of the Government of Japan

To transfer the knowledge to the counterpart personnels during the study

Attachment II

LIST OF ATTENDANTS

JAPANESE SURVEY TEAM

Dr. S. Naito	Chairman of the Study Team
Mr. K. Okazawa	Vice Chairman of the Study Team
Mr. K. Shiozawa	Staff of the Study Team
Mr. K. Miyakura	Staff of the Study Team

MWWA

Mr. Krachok Supkitvilekkarn	General Manager
Mr. Prathai Phisphumvidhi	Deputy General Manager for Engineering
Mr. Vibul Taweesup	Project Director, Separate Water Supply System
Mr. Ratana Suphanit	Assistant Project Director for Technical

DTEC

Mr. Tawal Polpuech	Chief of Colombo Plan Project
Mr. Sutin Susila	Division of External Cooperation-Office 2

JICA

Mr. R. Suwa

(3) Relationship Between Central and Separate Systems :

The review of the separate system in connection with the central system which was desired by M.W.W.A. was very complex, and it was necessary to acquire a detailed knowledge about the 1st stage construction of the central system. The construction schedule of the Bang Khen water treatment plant is as summarized below:

Central System:	1st Stage,	Phase 1	800,000 CMD
	1st Stage,	Phase 2	400,000 CMD
	2nd Stage		1,200,000 CMD

(Phase 1 Project is now under construction. The detail design of Phase 2 Project has been completed and the banks for Loan of Phase 2 Project is being looked for. The detail design of the 2nd Stage Project has not as yet been undertaken.)

The detail design of the Phase 1 Project of the central system was undertaken by C.D.M., and its construction is now under supervision of the U.S. consulting firm of Metcalf & Eddy. This consultant was said to refuse any comment on design problems and referred all questions to C.D.M. As a result, as it was reported to the survey team, the construction work sometimes posed problems. It was expected that similar problems would be encountered in the construction of the underground transmission line from the Bang Khen treatment plant to the major pumping stations. Especially because a transmission line of this sort had never been built in any southeast Asian country before, M.W.W.A. wanted an opinion from a third party. This was one of the important topics which was discussed in the second feasibility study.

On the other hand, the idea of connecting this transmission system to the separate system would arise as a result of the movement of people out of the central system service area into the separate system service area. It would become necessary to modify the plan of the separate system to charge the central system with supplying such a separate system service area with increasing population. In other words, while planning a long-term plan of the separate system, M.W.W.A. found it necessary to establish an organic connection between the

separate system and the centralsystems,and therefore desired that the Japanese study team would also study this question.

However, the diversion of water from the central system to the separate system could not be arbitrarily decided upon because each system was originally designed by C.D.M. to have an independent water source. It could not even be studied without going through the complicated process of review the design capacity of the central system. As already mentioned, the budget and time allotted to the Japanese study team did not permit the acceptance of this request from M.W.W.A. to include the study of the transmission system in the design.

The review of the separate system in connection with the central system was therefore, in principle, excluded from the Scope of Work of the feasibility study. However, the transmission line of the central system did in fact appear to be fraught with problems and it was of course not desirable to allow its construction work to proceed without some attempt at solving its problems. As M.W.W.A ardently desired the cooperation of the Japanese government in the solution of the problems, the study team suggested that these problems will be hopefully handled in some other proper way such as despatching of experts to Thailand.

(4) Outlook of Separate System:

The planning of the water supply in metropolitan Bangkok, including the reviewing of the separate system, is still in its very initial stage. A sufficient water supply is the prerequisite to the development of satellite cities around Bangkok city. To ensure a sufficient water supply, the question of water sources must be resolved.

As much water as needed can be obtained, if surface water is taken from a big river far away; but M.W.W.A., which alreacy faces a heavy financial burden by the construction of the central system project will be further pressed financially if an enormous investment is also to be made in the separate system. A practical approach to the implementation of the long-range separate system project would be to find temporary water sources which will get the project moving. To

find such water sources it is necessary to study the possibility of utilization of groundwater and water from the existing Klongs. The possibilities of water sources will be explored by the surveys designed on the basis of this feasibility study. From groundwater surveys, predictions can be made as to yields of aquifers over a wide area and the extent of salinification of groundwater. The surveys of the Klongs will reveal the contamination of water and from these predictions can be made as to the long-time suitability of the Klongs as a water source.

1-3-2 Interim Report and 2nd Field Survey (October 6 to November 14, 1977):

The Interim Report on the first field survey was prepared in Japan and the study team again visited Thailand on October 6, 1977 and presented the Interim Report to General Manager Mr. Krachok of M.W.W.A. on Octobr 11, 1977. Some members of the study team stayed in Thailand after the presentation of the Interim Report and engaged in the partial review of the separate system in connection with the central system, the sanitary surveys and the collection relevant data.

On November 10, 1977 the study team presented a report on the second field survey to Project Director Mr. T. Vibul and other related personnel of M.W.W.A.

The report contained information outlined as follows:

(1) Results of a field survey of the proposed transmission routes, service reservoir sites and booster pump station sites of the central system:

The proposed routes and sites mainly for the facilities to be built in the second and succeeding stages according to the master plan were surveyed. The suitability of the proposed routes and sites was commented upon and some alternative recommendations were made.

(2) Collection of data concerning the central system:

"A Review of the Bangkok Water Supply Phase 2 Project (Aug. 5, 1977)" released by M.W.W.A after the decision of the master plan was studied, and the construction work under way and the modifications were examined.

(3) Collection of data concerning the separate system:

1) Data concerning the deep wells under the jurisdiction of M.W.W.A.

2) Data concerning the deep wells outside the jurisdiction of M.W.W.A. and results of water quality analysis (at 18 points of sampling.)

3) Other supplementary data.

(4) Study of the facilities of the central system required to supply the separate system.

(5) Survey of the proposed transmission route for diversion of water from the service reservoirs of the central system to the separate system.

1-4 Feasibility Study Team Members and Cooperators

1-4-1 Members and Activities of Japanese Study Team:

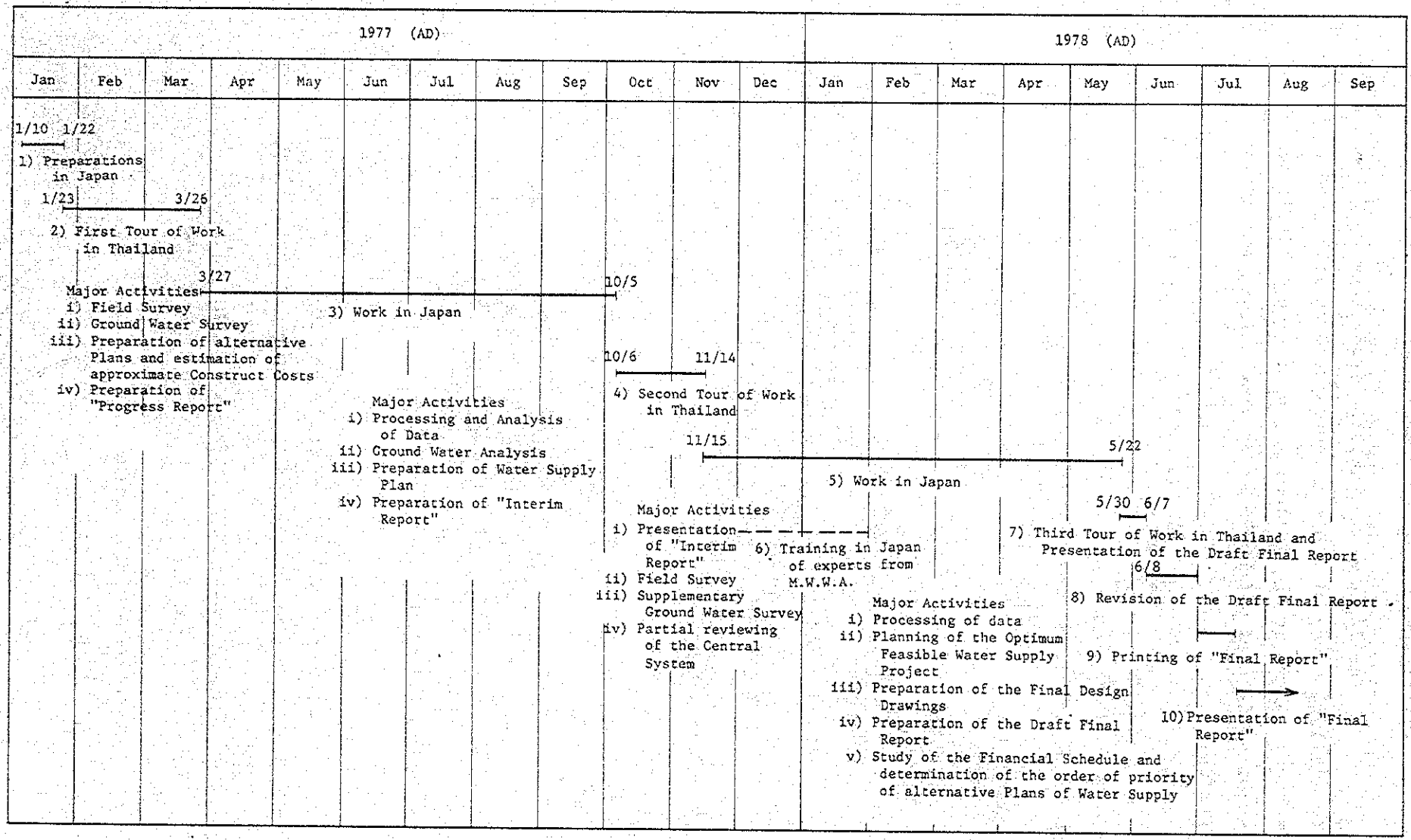
(1) Members of the Study Team:

Chairman	Dr. S. Naito	Advisor to Japan Water Works Association
Vice Chairman	Mr. M. Masuda	Water Works Section, Envitonmental Sanitation Department, Public Health Bureau, Ministry of Health and Welfare
Vice Chairman	Mr. K. Okazawa	Ditto
"	Mr. K. Nakamura	"
Member	Mr. K. Shiozawa	Nakanihon Engineering Consultant
	Mr. K. Kawamura	Ditto
	Mr. N. Muto	Pacific Consultants International
	Mr. T. Ogawa	Ditto
	Mr. S. Komatsu	Ditto
	Mr. E. Kawabata	Ditto
	Mr. Y. Nakamura	Nakanihon Engineering Consultant
	Mr. K. Miyakura	Pacific Consultants International
	Mr. Y. Hashiji	Nakanihon Engineering Consultant
	Mr. H. Takemoto	Pacific Consultants International

(2) Activities of the Study Team:

The Japanese feasibility study team conducted the second feasibility study of the separate system according to the study schedule shown in the following table. The table lists only the major activities which the study team carried out during the study period.

(3) Record of Activities of the Second Japanese Feasibility Study Team



Record of the First Field Survey (1977) :

Date	Day of Week	Note	Activity
Jan. 23	Sun.	Left Haneda for Bangkok by LH.	Dr. Naito, Mr. Okazawa and two other members left for Thailand.
Jan. 24	Mon.		Paid courtesy visit to Japanese Embassy, J.I.C.A. Office, and M.W.W.A.
Jan. 25	Tues.		Consulted M.W.W.A. (concerning S.W.)
Jan. 26	Wed.	Left Haneda for Bangkok by JAL717.	Eight study members left for Thailand. Consulted M.W.W.A. (Concerning S.W.)
Jan. 27	Thurs.		Made preparations and held general discussions.
Jan. 28	Fri.		Made arrangements with M.W.W.A. and visited Bang Phli and Bang Bo on the left bank (investigating the existing water supply facilities and water sources).
Jan.29 -30	Sat. -Sun.		Prepared materials and made map copies.
Jan. 31	Mon.		Visited Min Buri, Nong Chok and Lat Krabang on the left bank (investigating the existing water supply facilities and water sources).
Feb. 1	Tues.		Visited Non Khaem on the right bank (investigating the existing water supply facilities and water sources).

Date	Day of Week	Note	Activity
Feb. 2	Wed.		Visited Bang Yai, Bang Bua Thong and Sai Noi on the right bank (investigating the existing water supply facilities and water sources)
Feb. 3	Thurs.		Prepared a work plan and held general discussions about work schedule.
Feb. 4	Fri.		Held discussions with M.W.W.A. about the work plan and schedule.
Feb. 5	Sat.		Prepared data for use in field surveys.
Feb. 6	Sun.	Dr. Naito, Mr. Okazawa and Mr. Shiozawa left Bangkok for Japan.	Prepared data for use in field surveys.
Feb. 7	Mon.		Held discussions about the survey of the additional 5 Amphoes, took a field survey of Sai Noi and prepared for electric prospecting.
Feb. 8	Tues.		Held discussions with M.W.W.A. about the additional 5 Amphoes and carried out electric prospecting in Lat Krabang.
Feb. 9	Wed.		Made preparations for the sanitary survey, took a field survey of

Date	Day of Week	Note	Activity
			Bang Bua Thong, and carried out electric prospecting and collected data on groundwater in the district.
Feb. 10	Thurs.		Consulted the Industrial Estate Authority and the National Housing Authority; made field survey of Bang Khun Thian, and carried out electric prospecting and collected data on ground water on the right bank.
Feb. 11	Fri.		Collected water samples from the Klong Thawi Watthana, made a field survey of Bang Khun Thian, and carried out electric prospecting and collected data on groundwater on the right bank.
Feb. 12	Sat.		Discussed the work schedule and arranged data.
Feb. 13	Sun.		Arranged data.
Feb. 14	Mon.		Visited the Airport Office, took a field survey of Bang Phli and Bang Bo, and carried out electric prospecting and analytical test of groundwater on the right bank.
Feb. 15	Tues.		Surveyed water sources of Bang Phli and Bang Bo, and carried out electric prospecting and analytical test of groundwater on the right bank.

Date	Day of Week	Note	Activity
Feb. 16	Wed.		Consulted the National Housing Authority and arranged the data obtained from the Industrial Estate Authority. Carried out electric prospecting and analytical test of groundwater. (Electric prospecting on the left bank was completed.)
Feb. 17	Thurs.		Prepared a flow chart for sanitary survey, surveyed the water sources of Min Buri and Nong Chok, and carried out electric prospecting and analytical test of groundwater on the left bank.
Feb. 18	Fri.		Surveyed the water sources of Lat Krabang, and carried out electric prospecting and analytical test of groundwater on the left bank.
Feb.19-20	Sat.-Sun.		Made a rough sketch of the water supply plan and prepared a unit price list.
Feb. 21	Mon.		Arranged the data by electric prospecting in the additional 5 Amphoes and made an analytical test of groundwater.
Feb. 22	Tues.		Discussed data on ground water, consulted M.W.W.A., analyzed data and studied a rough water works plan.

Date	Day of Week	Note	Activity
Feb. 23	Wed.		Arranged and analyzed data, prepared a hydraulic plan and made preparations for electric prospecting in the 3 northern districts.
Feb. 24	Thurs.		Arranged data and collected data on electric prospecting and groundwater in the 3 northern districts.
Feb. 25	Fri.		Consulted the M.W.W.A. and carried out electric prospecting in the 3 northern districts. (Electric prospecting on the right bank was completed.)
Feb. 26	Sat.		Analyzed data, made a rough sketch of the water supply plan and prepared a unit price list.
Feb. 27	Sun.	Two groundwater specialists left Bangkok for Japan.	Ditto
Feb. 28	Mon.		Reviewed the rough sketch of the water supply plan and made preparations for water sampling.
Mar. 1	Tues.		Reviewed the rough sketch of the water supply plan, collected water samples and consulted the personnel of the Sam Sen treatment plant about the analysis of water samples.

Date	Day of Week	Note	Activity
Mar. 2	Wed.		Began to a plan of the water supply and collected water samples from the Nakhon Chai Si River.
Mar. 3	Thurs.		Worked on the plan of the water supply and collected water samples from the Klong Mae Nam Om and wells.
Mar. 4	Fri.		Worked on the plan of the water supply.
Mar. 5-6	Sat. - Sun.		Arranged water samples and data and held a discussion.
Mar. 7	Mon.		Worked on the plan of the water supply.
Mar. 8	Tues.		Worked on the plan of the water supply and collected water samples from the Chao Phraya river.
Mar. 9	Wed.		Collected water samples from the Nakhon Chai Si river and began to prepare a progress report.
Mar. 10	Thurs.		Surveyed the existing roads, collected water samples from the Klongs and wells in the 3 eastern districts and worked on the progress report.
Mar. 11	Fri.		Surveyed the existing roads, collected water samples from the Klongs and wells in the 2 southern districts and worked on the progress report.

Date	Day of Week	Note	Activity
Mar. 12	Sat.		Prepared drawings and arranged data.
Mar. 13	Sun	Dr. Naito, Mr. Okazawa and Mr. Shiozawa left Haneda for Thailand.	Ditto
Mar. 14	Mon.		Visited J.I.C.A. office and M.W.W.A. and worked on the progress report.
Mar. 15	Tues.		Visited P.W.D. and D.T.E.C. and worked on the progress report.
Mar. 16	Wed.		Drafted the progress report and began translation into English.
Mar. 17	Thurs.		Continued progress report drafting and translation.
Mar. 18-19	Fri. - Sat.		Typed manuscript of draft progress report and prepared drawings and tables.
Mar. 20	Sun.		Prepared drawings.
Mar. 21	Mon.		Typed manuscript of draft progress report and checked English translation against Japanese original.
Mar. 22	Tues.		Made a preliminary presentation to M.W.W.A., pigeonholed the manuscripts and checked the progress report.

Date	Day of Week	Note	Activity
Mar. 23	Wed.		Copied and bound original progress report, and prepared explanatory drawings for M.W.W.A.
Mar. 24	Thurs.		Made a final presentation of the first field survey to M.W.W.A. (in presence of its general manager and related personnel).
Mar. 25	Fri.		Visited Japanese Embassy, J.I.C.A. office and M.W.W.A. to say parting words.
Mar. 26	Sat.	Left Bangkok for Tokyo by JAL466.	

Record of the Second Field Survey (1977) :

Date	Day of Week	Note	Activity
Oct. 6	Thurs.	Dr. Naito, Mr. Masuda, Mr. Kawamura, Mr. Komatsu, Mr. Miyakura and Mr. Hashiji left Haneda for Bangkok by JAL465.	
Oct. 7	Fri.		Paid courtesy visit to Japanese Embassy, J.I.C.A. office, M.W.W.A., and D.T.E.C.
Oct. 8-9	Sat.-Sun.		Prepared supplementary data for the interim report.
Oct. 10	Mon.		Briefed on the interim report to Mr. T. Vibul and other personnel of M.W.W.A.
Oct. 11	Tues.		Briefed on the interim report to General Manager Mr. Krachock of M.W.W.A.
Oct. 12	Wed.		Made preparations for review of central system.
Oct. 13	Thurs.		Made preparations for review of central system and discussed review procedures.

Date	Day of Week	Note	Activity
Oct. 14	Fri.	Dr. Naito and Mr. Masuda left Bangkok for Japan by JAL466	Arranged data and collected data for review of central system.
Oct. 15	Sat.		Ditto
Oct. 16	Sun.		Ditto
Oct. 17	Mon.		Made preparations for a supplementary sanitary survey and consulted Sanitary Engineer Mr. Haga working for the Colombo Plan.
Oct. 18	Tues.		Held discussions about the supplementary sanitary survey and work schedule.
Oct. 19-20	Wed.-Thurs.		Prepared schedule for supplementary sanitary survey (in English) and review of central system.
Oct. 21-22	Fri.-Sat.		Made preparations and drew a plan for review of the central system and a route survey.
Oct. 23	Sun.		Arranged data.
Oct. 24	Mon.		Took a field survey of proposed route of diversion of water from central system and its proposed service reservoir sites.
Oct. 25	Tues.		Continued the above field survey and consulted personnel of Sam Sen treatment plant about water analysis.

Date	Day of Week	Note	Activity
Oct. 26	Wed.		Continued the above field survey.
Oct. 27-28	Thurs.-Fri.		Continued the above field survey and collected data on ground water.
Oct. 29	Sat.		Discussed the results of the field survey and reviewed the route maps.
Oct. 30	Sun.		Arranged drawings.
Oct. 31	Mon.		Made a summary of the results of the field survey, collected water samples from wells, and had interviews.
Nov. 1-2	Tues.-Wed.		Made hydraulic calculations required for review of central system, collected water samples from wells, and had interviews.
Nov. 3	Thurs.		Made hydraulic calculations required for review of central system, and collected and arranged data on wells.
Nov. 4-6	Fri.-Sun.		Reviewed central system (by making drawings), and arranged data obtained by the well survey.
Nov. 7-8	Mon.-Tues.		Made a summary of results of second field survey, collected water samples from wells, and had interviews.
Nov. 9	Wed.		Continued to make a summary of results of second field survey, and arranged data on wells.

Date	Day of Week	Note	Activity
Nov. 10	Thurs.		Typed manuscript for report on second field survey, copied and bound original draft. Discussed results of second field survey with M.W.W.A. personnel.
Nov. 11	Fri.		Made a presentation of second field survey to J.I.C.A. office (in Bangkok), and arranged supplementary data.
Nov. 12	Sat.		Arranged supplementary data.
Nov. 13	Sun.		Made preparations for departure, and arranged data.
Nov. 14	Mon.	Mr. Kawamura, Mr. Komatsu, Mr. Miyakura and Mr. Hashiji left Bangkok for Japan by JAL768	

(3) Documents Submitted to M.W.W.A. During Second Field Survey :

The following documents, some evidencing agreement between J.I.C.A and M.W.W.A., and some summarizing the activities of the feasibility study team, were submitted to M.W.W.A. at various times during the feasibility study and generally as follows:

1)	Scope of Work	(Written agreement dated January 26, 1977)
2)	Inception Report	(Written report dated January 28, 1977)
3)	Progress Report	(Written report dated March 24, 1977)
4)	Interim Report	(Written report dated October 11, 1977)
5)	Memorandum of Second Survey	(Written report dated November 10, 1977)
6)	Draft Final Report	(Written report dated June 2, 1978)
7)	Final Report	(Written report to be submitted in July 1978)

1-4-2 Cooperators for Second Feasibility Study :

The second feasibility study was conducted with helpful cooperation of many personnel from the government agencies of both Japan and Thailand. The following is a partial list of such persons, and many thanks is also due to many other people for their helpful cooperation and valuable advice.

Thailand :

MWWA	General Manager	: Mr. Krachok Supkitvilekkarn
"	Deputy General Manager for Engineering	: Mr. Prathai Phisphumvidhi
"	Deputy General Manager for Administration	: Mr. Pandit Jankarnkit
"	Director of Capital Development Project Office	: Mr. Birabandthu Tungasvadi
"	Director of Project Planning and Control Division, Project Director, Separate Water Supply System Project	: Mr. Vibul Taweesup
"	Chief of Research and Development Division	: Mrs. Chuanpit Dharmasiri
"	Deputy Director of Project Planning and Control Division, Assistant Project Director, Separate Water Supply System Project for Technical	: Mr. Ratana Suphanit
"	Assistant Project Director, Separate Water Supply System Project for Administration	: Miss Sumitmai Dharmasaroj
"	Staff of Project Planning and Control Division	: Mr. Boriraksa Dasanonda
"	Staff of Project Planning and Control Division	: Mr. Prasat Silphipat
"	Staff of Research and Development Division	: Mr. Varavut Wongvises
"	Staff of Project Planning and Control Division	: Mrs. Thidachan Somprasong
DTEC	Chief of Colombo Plan Project	: Mr. Tawal Polpuech
"	Division External Cooperation - Office 2	: Mr. Sutin Susila

CHAPTER 2 DISCUSSION AND RECOMMENDATIONS

CHAPTER 2

DISCUSSION AND RECOMMENDATIONS

2-1 Consideration of Adjacent Development Area

If the survey which was taken of 5 out of the 9 Amphoes to be covered by the separate system in 1972 is called as a first feasibility study, the survey which was taken by J.I.C.A. in 1977 can be called as a second feasibility study.

The second feasibility study began with a field survey which was continued for a period of two months from January 23 to March 26, 1977. On the first day of the visit of the Japanese survey team to Bangkok it was requested by the authority of Thailand to include the following investigations in the scope of its activities.

1) Adjacent industrial and/or residential area relating to the 9 Amphoes :

2) Review of the central system :

After being discussed it was agreed between M.W.W.A. of Thailand and J.I.C.A. of Japan that the J.I.C.A. would include 1) in its survey where possible; and undertake 2) only "in case it would be better for the separate system to divert water from the central system".

The adjacent industrial and/or residential area which is to be included in the scope of this feasibility study is divisible into 8 districts where 5 housing projects, 5 industrial development projects; and a new airport project are considered.

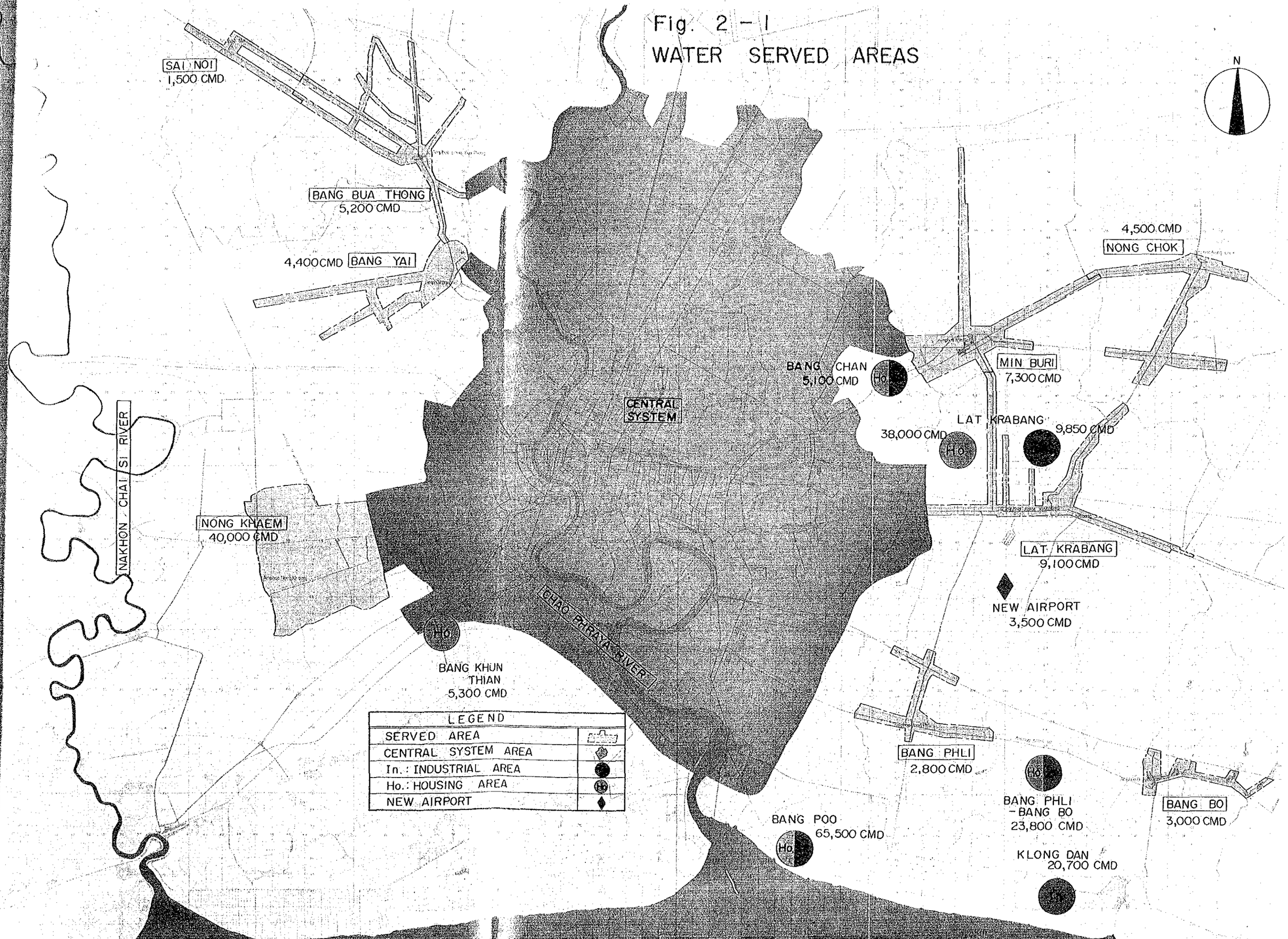
The entire water supply project of separate system becomes quite complex, when the adjacent industrial and/or residential area are included. Water demand of the entire water supply system in 2000 is estimated at 171,750 CMD, more than two fold the demand in the existing Amphoes (77,800 CMD in 2000 AD).

However, these adjacent development area projects play a significant role in the decentralization of the metropolitan population and sub-urban development; and viewing of their significance on a national level,

the 8 adjacent development areas has been determined including in this feasibility study.

The location of the adjacent development areas, entire served area and water demand are shown in Fig. 2-1.

Fig. 2 - 1
WATER SERVED AREAS



2-2 Water Sources

2-2-1 Groundwater :

The most important question in the feasibility study of the separate system is where to find an economically feasible water source. However, the fact must be faced that a water source which is rich, safe and cheap is extremely difficult to find, especially so when the separate system is to be expanded to cover the entire development program area.

It was revealed by electric prospecting survey that there were 8 aquifers at differing depths in the area to be supplied by the separate system. The data of the EGAT indicates that the four aquifers below 300 m yield are poor quality water and are not adequately recharged, and that the upper two aquifers are contaminated. Accordingly, the project area has only two aquifers (at a depth of 150 to 200 m below ground surface) which can be safely tapped.

In the metropolitan Bangkok area, however, about 900,000 CMD of water is drawn from the two aquifers, and the rate of withdrawing fresh water far exceeds the rate of recharge and to the extent that saline water intrudes these water supply aquifers for a distance as great as 900 m or so each year.

The legal restrictions of the use of groundwater in Thailand are not a subject of this feasibility study. Legal protection against unrestrained use of groundwater cannot be expected for the present. In any case, M.W.W.A. - which already withdraws nearly 320,000 CMD of water - should not overpump groundwater more than recharge amount.

The study for the recharged amount of the separate system was carried out by the procedure as shown in Fig. 2-2.
As a result of multiple studies, it appears that the vertical recharge cannot be relied on due to distribution of impermeable clay layers within the study area.

On the other hand, about 54,300 CMD of water can be expected from the holizontal recharge in the study area; thus, it can fill the demand of 37,800 CMD for the existing 8 Amphoes, excluding Nong Kheam; however, it cannot meet the total demand of 249,550 for the entire served area including the adjacent development areas.

Furthermore, when the undesired consequences of over-pumping in Bangkok and its vicinity are taken into account, the limit of groundwater pumpage should be determined after an extensive and detailed study.

The community people of the existing 8 Amphoes have long sufferred from a water supply shortage and should therefore be accorded the privilege of using groundwater by priority since there is a limit to the yield of this water source. The adjacent industrial and/or residential area should be supplied with water from other source, except for Bang Chan where a water supply project which plans to tap 5,100 CMD of groundwater is already under way. Accordingly, the total amount of groundwater which the entire separate system will be allowed to withdraw will be limited to 42,900 CMD.

2-2-2 Surface Water :

When the use of groundwater is limited only to the existing 8 Amphoes, the adjacent development area cannot be supplied with groundwater. To supply this area is will be necessary to tap other sources like the Klong or a river. (The discussion of the central system will be deferred to Sec. 2-3).

As already pointed out in the feasibility study of 1973, the Klong water is markedly contaminated by organic matter so that the 5-day BOD of smaller Klongs such as the Klong Thawi Watthana and Phra Khanong is already as high as 5 ppm. The contamination of the Klong water has advanced to such extent that the smaller Klongs have been disqualified one after another for a source of water supply.

On the other hand, relatively larger Klongs like Sam Wa and Sip Sam still yield not only quantity but also quality for the drinking purposes. The detailed discussion of the Klongs as a water source will be deferred to a later chapter. Both the observed and assumed values of 5-day BOD of the water of Klong Sam Wa are below 1 ppm so that it well qualifies as a source of potable water. However, its tapping is another study, since the Royal Irrigation Department (RID) has the water rights to the Klongs. M.W.W.A. should

therefore, firstly sound out RID regarding the possibility of tapping the Klongs as a water source. Any plan to tap the Klongs which will not be approved by RID is nothing but a house of cards.

The use of river water, on the other hand, presupposes the development of a new water source. The development of such a new water source is not a problem of the separate system alone but a basic one which the Greater Bangkok Water Works, including the central system, now faces. M.W.W.A. which now depends on only the Chao Phraya river for a water supply source should take action as early as possible to study the possibility of tapping the other rivers including the Nakhon Chai Si river which has a suitable intake site about 80 km upstream from its estuary.

Many of the problems concerning the use of surface water are political as well as technical, as mentioned above. Since the separate system is required to commence service as soon as possible, M.W.W.A should begin negotiations with the competent authorities as early as possible in order to acquire the water rights to the Klong and should lay out a plan to tap rivers as a spare, if it decides to rely on surface water to fill the demand on the separate system.

An attempt to even overpump groundwater to fill the demand on the separate system instead of using a political and technical approach for tapping the Klongs or rivers should in no case be allowed. Should it be allowed, M.W.W.A. will have to take such serious consequences as the land subsidence of the Greater Bangkok area and the intrusion of sea water into the water supply aquifers in the area.

Fig.2-2 Study of Recharge